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Illinois Natural History Survey
1816 S. Oak Street
Champaign, IL 61820

Final Report for W-183-R-6: Wild Turkey Responses to Forest Management

Hoover, Jeffrey P.; Parker, Christine M.; Meador, Morgan T.; Benson, Thomas J.

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Final Report for W-183-R-6

Wild Turkey Responses to Forest Management

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f) Principle Investigator(s): Jeff Hoover, Avian Ecologist, Illinois Natural History Survey, University of Illinois, 1816 S. Oak Street, Champaign, IL 61820, (217-244-2922); Thomas J. Benson, tjbenson@illinois.edu (217-265-6242); Christine M. Parker, cmroy2@illinois.edu (518-637-7915)

g) PhD student: Christine Parker, cmroy2@illinois.edu
MS student: Morgan Meador, mwomack@illinois.edu

h) IDNR Project Managers: Luke Garver, Luke.Garver@illinois.gov; Paul Shelton, Paul.Shelton@illinois.gov

Overview and Objectives

Lack of disturbance has led to the degradation of Illinois forests and open woodlands. As with forests throughout the Midwest, these historically oak-dominated systems are transitioning into closed-canopy forests that are dominated by shade-tolerant species such as maples. Much of this transition has been attributed to the exclusion of both anthropogenic and natural fires from contemporary landscapes (Abrams and Nowacki 2008). Beyond encroachment of shade-tolerant native species, the understory layers of many Midwestern forests and open woodlands have become encroached with exotic species such as honeysuckle (*Lonicera* spp.) or buckthorn (*Rhamnus* spp.). These large-scale alterations of forest and woodland ecosystems have adversely impacted numerous conservation-priority wildlife species that have historically depended on relatively open oak-dominated systems, including red-headed woodpeckers, whip-poor-wills, and wild turkeys.

Aside from being potential indicators of ecosystem health, wild turkeys are an economically important game species. Accordingly, considerable research attention has focused on understanding broad-scale habitat associations of turkeys and estimating demographic parameters. Forests or woodlands with mature trees are known to provide habitat that is preferred by turkeys for parts of their annual cycle (Miller et al. 1999), but turkeys have extensive and seasonally variable home ranges (e.g., <1 to 32 km^2; Thogmartin (2001), Badyaev et al. (1996a)). The importance of different habitat components is likely seasonally dependent, with food availability and safety from predators being important year-round, but with quality nesting and brood-rearing habitat being important during spring and summer. Aspects of vegetation structure and composition, including understory density, are known to influence nest-site selection and reproductive success (Badyaev 1995, Badyaev et al. 1996b, Locke et al. 2013), but quantitative information on important habitat characteristics during other stages of the annual cycle is generally lacking. Beyond influencing habitat use, the structure and composition of vegetation

may influence the frequency and distance of movements, quantities negatively associated with survival (Hubbard et al. 1999). However, despite the numerous links between vegetation structure and aspects of wild turkey habitat use and demography, information on turkey responses to management actions is generally lacking. One additional factor, black flies (*Simulidae*) (Adler et al. 2004), may play a role in limiting wild turkey reproductive success, particularly in western Illinois. While black flies have been documented reducing breeding success in some bird species (Smith et al. 1998, Solheim et al. 2013, Franke et al. 2016), their effect on wild turkey populations is unknown.

To better understand the response of wild turkeys to forest management activities and black flies, the objectives of Segment 6 of the Wild Turkey Responses to Forest Management research project were to:

1) Continue radio-tracking Wild Turkey hens captured during the previous segment and capture and affix radios to an additional 40 hens to enhance sample sizes across study sites;

2) Use micro-GPS telemetry to examine the effects of forest management, habitat and landscape features, and black flies on Wild Turkey habitat use, survival and reproductive success, emphasizing central and western Illinois sites;

3) Use micro-GPS telemetry, accelerometer data, and insect surveys during the breeding season to document potential effects of black flies on hen turkey incubation behavior, hen and nest mortality, and possibly poult survival;

4) Provide one popular article about this project to the Illinois Department of Natural Resources by the grant end date. This article will be approximately 500 words in length with at least 2 pictures provided.

Methods

Given the importance of adequate nesting and brood rearing habitat to wild turkey demographics (Badyaev 1995, Thogmartin 1999, Thogmartin and Johnson 1999, Spears et al. 2007, Fuller et al. 2013), our primary focus is on the movements, habitat selection and survival of turkey hens throughout their annual cycle in areas where forests are actively being managed in ways that are intended to promote favorable nesting and brood rearing habitat.

Study Sites. We conducted this research at locations in central and western Illinois. Sites in central Illinois included Hidden Springs State Forest (Hidden Springs) and Ramsey Lake State Park (Ramsey Lake), while sites in western Illinois included two privately-owned sites (Twin Rivers Sow Incorporated and Pasa Park). Additional baiting occurred at an additional private property adjacent to Hidden Springs. At Hidden Springs, there has been forest management during the past decade (e.g. non-managed areas, and maple and exotic plant control with and without frequent fire) resulting in some prerequisite forest units needed to study the effects of forest management on hen turkey habitat use throughout an annual cycle. At Ramsey Lake, there is a long and well-documented history of forest management, particularly prescribed fire and some thinning. This site also has a decent turkey population and some areas of forest that are not managed. We expected that the central Illinois sites would have few to no black flies present. We continued to work on private sites in western Illinois where turkeys had been captured in the previous season because we were still monitoring individuals from the previous year and turkey flocks were again observed on sites prior to or during the 2019 capture season. These privately-owned sites have had limited forest management historically (e.g., thinning, prescribed fire), and should have high numbers of black flies during the period of time when their emergence occurs.

Capture and Tracking of Turkeys. We captured turkeys using cannon nets (i.e. Netblasters) at sites baited with cracked corn during winter (mid-January - March) of 2020. Each

captured bird was banded with an aluminum rivet leg band. Age of each captured individual was determined by evaluating the shape, wear, and barring on the 9th and 10th primaries (Leopold 1943), and sex was determined using a combination of morphological features (e.g., caruncle coloration, beard presence, leg spur presence and length, breast-feather coloration. Every hen and some males were fitted with a MiniTrack or PinPoint µGPS transmitter (Lotek Wireless Inc., Ontario, Canada). We released all birds at the capture site immediately after processing. Transmitters were programmed to record a location every 30 minutes during daylight hours (e.g. 0500-1900 hours) and one location at midnight (i.e., 28 locations daily) between time of capture till the end of June. After June, the transmitters were programmed to record a location every two hours during daylight hours and one location at midnight (i.e. 9 locations daily). Each µGPS unit is also equipped with a dual axis activity sensor which records forward-backward (x-axis) and left-right (y-axis) movements (Lotek user manual, revised 2018). Activity is measured simultaneously on each axis four times per second, and recorded as the difference in acceleration between consecutive measurements within a range of 0 to >800. These measurements (x and y) are averaged over one-minute intervals. Values < 20 are not considered active movement.

Based on this transmitter configuration, we expected the units to collect data for up to approximately one year. Remote download of the stored location and activity data on transmitters permits us to collect the data without disturbing nesting hens or influencing turkey movements. Each µGPS-marked bird was relocated every week during the breeding season and bi-weekly during the non-breeding season, using a 3-element Yagi antenna and a receiver (R-1000, 148-160 MHz, Communications Specialists Inc.). Upon relocation of a bird, we positioned ourselves within 500 m of each bird to facilitate use of a Handheld Command Unit (HCU; Lotek Wireless Inc., Ontario, Canada), and remotely downloaded location and activity data from the µGPS unit. Individual birds were monitored until death of the animal or the end of the life of the

μGPS unit. These methods were approved by the University of Illinois at Urbana-Champaign Institutional Animal Care and Use Protocol (#17291).

Nest, Hen, and Brood Survival. We will use known-fate or other appropriate models (Allison 2011) to estimate the survival rates of hens and nests. In the results we currently report summaries of the fates of nests and radioed birds, and during the next segment we will continue to develop and complete the survival rate models for hens and nests and will provide those as they are completed.

Nest fate. We used location and activity data from μGPS-monitored hens to determine nest locations. Hatch dates were estimated based on the date when activity data first indicate a hen had low movement values (i.e., ≤ 15) for about 22-23 hours per day, indicating incubation had begun. After 28 days of incubation (Paisley et al. 1998), each nest was located to determine nest fate. Nests where egg shells remained mostly intact (i.e., not crushed or scattered) were classified as successful and attempts were then made to obtain visual confirmation of poults with the hen. Nests were classified as failed, and presumed predated, if egg shells were found smashed and scattered and no poults observed with the hen during the following week. If a hen terminated incubation early (< 28 days), the nest location was visited immediately to determine nest fate, and was classified abandoned if eggs were intact, or predated if eggs were destroyed.

Hen fate. During the breeding season, hens were monitored once weekly to download data and check for a mortality beacon. Each μGPS was programmed to emit a mortality beacon after 32 hours of inactivity. Unpublished data suggest that hens may sometimes remain on the nest for ≥ 24 hours during inclement weather which produces a false mortality signal. If a mortality signal was detected, hens were located, and intact carcasses collected for necropsy at the University of Illinois Veterinary Diagnostic Laboratory. Any signs observed at the carcass location, indicating predation by a specific animal (e.g., fur, feathers, tooth or claw marks, etc.),

were noted. Due to the difficulty of identifying predator species without direct observation, we only seek to determine if predation was the cause of death.

Brood Surveys. For hens with successful nests, brood surveys were conducted weekly for up to 8 weeks. These hens were located via telemetry each week following a successful hatch. Each week hens were directly observed one time when possible to determine whether there were any poults with her (yes, no, uncertain) and to record the maximum number of individual poults observed.

Nest-site Vegetation Surveys. Several parameters were measured at each nest site as well as a paired "non-nest" location (80 m from each nest, in a randomly-determined direction) associated with each nest. To evaluate visual obstruction around turkey nests, we measured the distance to the nearest obstruction (e.g. foliage or stems) above the nest up to 5 m. Visual obstruction at 15 m from a nest was also recorded whereby a technician held a density board (Nudds 1977) at the nest bowl facing the direction of a 2nd technician located 15 m from the nest. The 2nd technician then estimated and recorded an index of vegetation cover for each height class represented on the density board, including 0-50 cm, 51-100 cm, and 101-200 cm above ground level. Cover index values are [1] < 2.5%, [2] 2.5 – 25%, [3] 26 – 50%, [4] 51 – 75%, [5] 76 – 95%, and [6] > 95%. This visual obstruction at 15 m survey was conducted in each the cardinal direction from the nest bowl. Density board visual obstruction surveys were also completed in various management units at both Hidden Springs and Ramsey Lake, to compare the amount of cover among different types of forest management (e.g., prescribed fire, thinning, and no management), and also determine the management type that best matched where turkeys were nesting.

Black Fly Monitoring. During mid-April – June 2020, we qualitatively assessed black flies weekly among the western and south-central study sites where turkeys were being

monitored. We would have quantified flies using CO2 traps, but were unable to do so because of the limitations imposed by the COVID-19 pandemic (see black fly results below for further explanation). In forthcoming analyses we will evaluate the relationship between wild turkey nesting success (manuscript in prep by M. Meador), incubation behavior (recess frequency and duration; manuscript in prep by C. Parker), black fly abundance, and nest-site habitat.

Camera Trap Data. To evaluate the nest/hen predator community in the 4 study areas where turkeys were captured in 2020 (Hidden Springs State Forest, Twin Rivers Sow Farm, Pasa Park, and Ramsey Lake State Park), we conducted trail-camera surveys during May – June 2020. Eight cameras (2 at Hidden Springs, 2 at Twin Rivers Sow Farm, 2 at Pasa Park, and 2 at Ramsey Lake State Park) were deployed, each for 6 1-week periods between approximately 16 May and 28 June, corresponding with when the peak of turkey nesting and early poult rearing periods should occur. Camera trap locations on each site were established to maximize coverage and were placed within forest habitat at least 500 m apart from each other. Cameras were baited with fatty-acid tablets to attract mesocarnivores and potential nest/hen predator species, and images were downloaded weekly. Cameras took heat/motion sensed images whenever triggered. For a given type of animal, once a capture event occurred, at least 30 minutes had to pass before a "new" capture event could be counted. Average daily capture rates were estimated for each type of animal at each camera. Mean capture rates were calculated and compared for each of the 4 sites for each species detected.

Ongoing Data Analyses. Analyses of the effects of black flies, land cover features, vegetation characteristics, and weather on turkey nest survival are being completed and will be featured in a manuscript by M. Meador that is in draft form. We are also currently compiling activity data to analyze different hen behaviors. Specifically, we will use these data to describe incubation recess behavior (e.g., daily recess frequency, duration of recesses, and when recesses

occur) among hens and whether recess behavior influences nesting mortality (hen and nest survival). We will also use these data to describe loafing behavior in turkeys, including when and where loafing occurs.

(ii) Actual Accomplishments vs. Project Objectives

a) **Objective 1** – Continue radio-tracking Wild Turkey hens captured during the previous segment and capture and affix radios to an additional 40 hens to enhance sample sizes across study sites.

This segment represents the sixth year of an ongoing project. We were able to continue monitoring during fall 2019 the turkeys with transmitters still working and had a successful capture season in winter 2020. We baited for turkeys among several sites and had good attendance by turkeys at bait locations in both south-central Illinois region and western Illinois. The now three Netblasters that we had worked well and captured 31 new turkeys during the winter 2020 capture season. These captured birds included 22 new hens with 11 hens fitted with transmitters at Hidden Springs (south-central Illinois), 5 hens at Ramsey Lake (south-central Illinois) and 6 at private sites in western Illinois. Additional carryover hens from 2019 with functioning transmitters included 9 at Hidden Springs and 6 in western Illinois.

b) **Objective 2** – Use micro-GPS telemetry to examine the effects of forest management, habitat and landscape features, and black flies on Wild Turkey habitat use, survival and reproductive success, emphasizing central and western Illinois sites.

During this segment we were able to get nesting data from hens in the two regions of study (western Illinois with many black flies and south-central Illinois with few) including at sites with ongoing forest management (Hidden Springs and Ramsey Lake) so we should be able to meet

this objective. We now have 2 years of data with more than 30 nesting attempts in each year, and will meet this objective with ongoing analyses.

c) **Objective 3** – Use micro-GPS telemetry, accelerometer data, and insect surveys during the breeding season to document potential effects of black flies on hen turkey incubation behavior, hen and nest mortality, and possibly poult survival.

We completed counting black fly samples from 2019, assessed black flies qualitatively during 2020, and continue to manage databases, and initiate the modelling required to meet this objective. C. Parker is working on a draft manuscript documenting incubation behavior in turkey hens based on weekly black fly abundances. We were able to document the duration and intensity of black fly emergence in 2018 and 2019 (and qualitative patterns for 2020) while also documenting the timing of breeding for hen turkeys in the same sites. The timing of black fly emergence overlaps substantially with the incubation and early poult rearing periods of the hens we monitored, so we know there is the potential for black flies to have an effect on hens and their nesting success.

d) **Objective 4** – Provide one popular article about this project to the Illinois Department of Natural Resources by the grant end date. This article will be approximately 500 words in length with at least 2 pictures provided.

The article ‘Using Digital Image Analysis to Quantify Small Arthropod Vectors’ we submitted for publication in the Journal of Medical Entomology was published in April 2020. We are currently preparing a manuscript describing hen habitat selection in response to prescribed fire, and will be submitting it this fall (2020) to the journal of Forest Ecology and Management.

Results and Discussion

General. During late January through March 2020, we baited and trapped at multiple locations at Ramsey Lake State Park, Hidden Springs, and at privately-owned sites in Pike County Illinois. Turkeys responded well to baiting efforts during the 2020 season, and we had turkeys carryover from 2019 that remained active. Compared to the 2019 capture season, weather wasn't as favorable for trapping (e.g. wet/warm winter and early spring); however, we were able to capture turkeys in Fayette, Shelby, and Pike Counties. Previously successful private land sites (e.g. Twin River Sow Incorporated), did not yield any successful days of capture. We did add an additional private land site in Pike County, Pasa Park (managed by George Metcalf) under the recommendation of Tim Krumwiede (district biologist for Pike County). We exclusively used the Netblaster, and having three available units did increase our trapping capabilities.

Capture Information. We captured 31 turkeys, and radio-tagged a total of 29 turkeys during the 2020 trapping season. At Pasa, one juvenile male and six adult females were banded and marked with µGPS units. Two juvenile males were banded, but not radio-tagged at Pasa. At Ramsey Lake State Park, six juvenile males and 5 adult females were banded and marked with µGPS units. At Hidden Springs, 2 juveniles (1 F; 1M) and 10 adult females were banded and marked with µGPS units.

Nesting Information. Turkeys initiated incubation of first nests during late April and early May among sites in 2020 (Table 1; Table 2; Table 3). Two nests were monitored at Twin Rivers Sow Inc. (Figure 1). Four nest attempts were observed at the Pasa (Figure 1). Twenty-four nests were monitored at Hidden Springs (Figure 2). Five nest attempts were monitored at Ramsey Lake State Park (Figure 3). Of the 35 nests detected in 2020, six succeeded into the poult stage (poults observed with hen) which is the most we have had with our research to date; three were

classified as unknown (could not determine fate due to land-access issues), 10 nests did not progress into the incubation stage (i.e. abandoned or depredated while egg laying), 14 nests were depredated, and two nests failed due to hen mortality. Nine of the 35 attempts were unsuccessful renests. We did have a tagged hen from the 2019 cohort (whose transmitter was still functioning) make 4 nesting attempts, which is a first for our project. While nesting success rates were low, they were the highest we have had and are comparable or even higher than some other reported rates (e.g., Conley et al. 2016).

Table 1. Summary of first initiation of incubation dates (i.e., first day of incubation) by wild turkey hens in Pike County, Illinois during 2017-2020.

Nesting parameter	2017	2018	2019	2020
Mean first-nest initiation	18-May	5-May	1-May	7-May
Median first-nest initiation	17-May	4-May	2-May	6-May
Earliest first-nest initiation	24-Apr	29-Apr	23-Apr	29-Apr
Latest first-nest initiation	11-Jun	16-May	10-May	18-May

Table 2. Summary of first initiation of incubation dates (i.e., first day of incubation) by wild turkey hens in Shelby County, Illinois in 2015-2017 and 2019-2020.

Nesting parameter	2015	2016	2017	2019	2020
Mean first-nest initiation	22-Apr	29-Apr	24-Apr	6-May	12-May
Median first-nest initiation	22-Apr	28-Apr	22-Apr	6-May	12-May
Earliest first-nest initiation	12-Apr	15-Apr	20-Apr	24-Apr	28-Apr
Latest first-nest initiation	30-Apr	17-Apr	2-May	7-June	29-May

Table 3. Summary of first initiation of incubation dates (i.e., first day of incubation) by wild turkey hens in Fayette County, Illinois in 2020.

Nesting parameter	2020
Mean first-nest initiation	11-May
Median first-nest initiation	16-May
Earliest first-nest initiation	23-Apr
Latest first-nest initiation	19-May

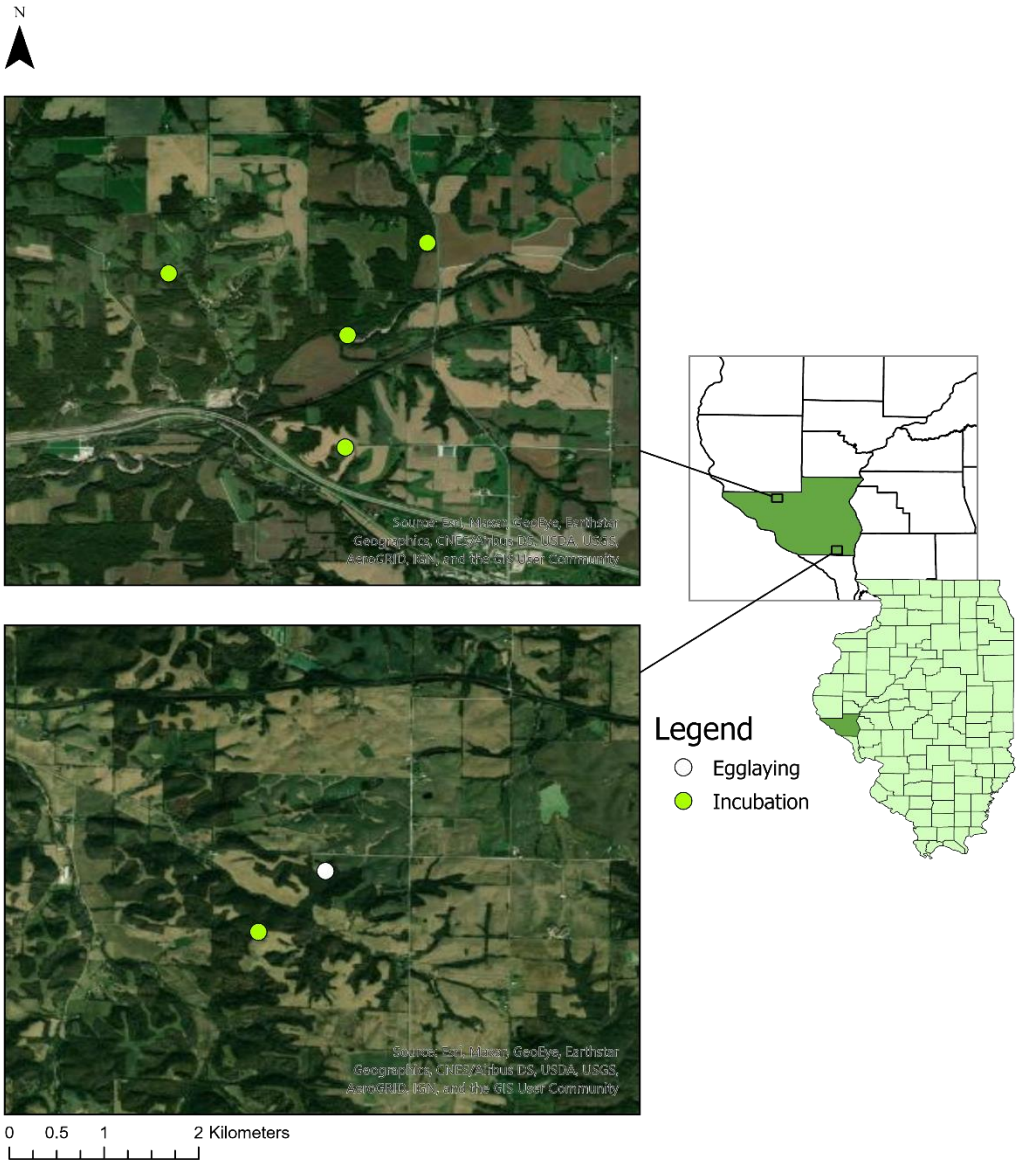

Figure 1.Nest locations for Pasa (top panel) and Twin Rivers Sow Inc. (bottom panel) in Pike County, Illinois, USA, 2020. We separated egg laying attempts (white circles) from nests that were incubated (green circles).

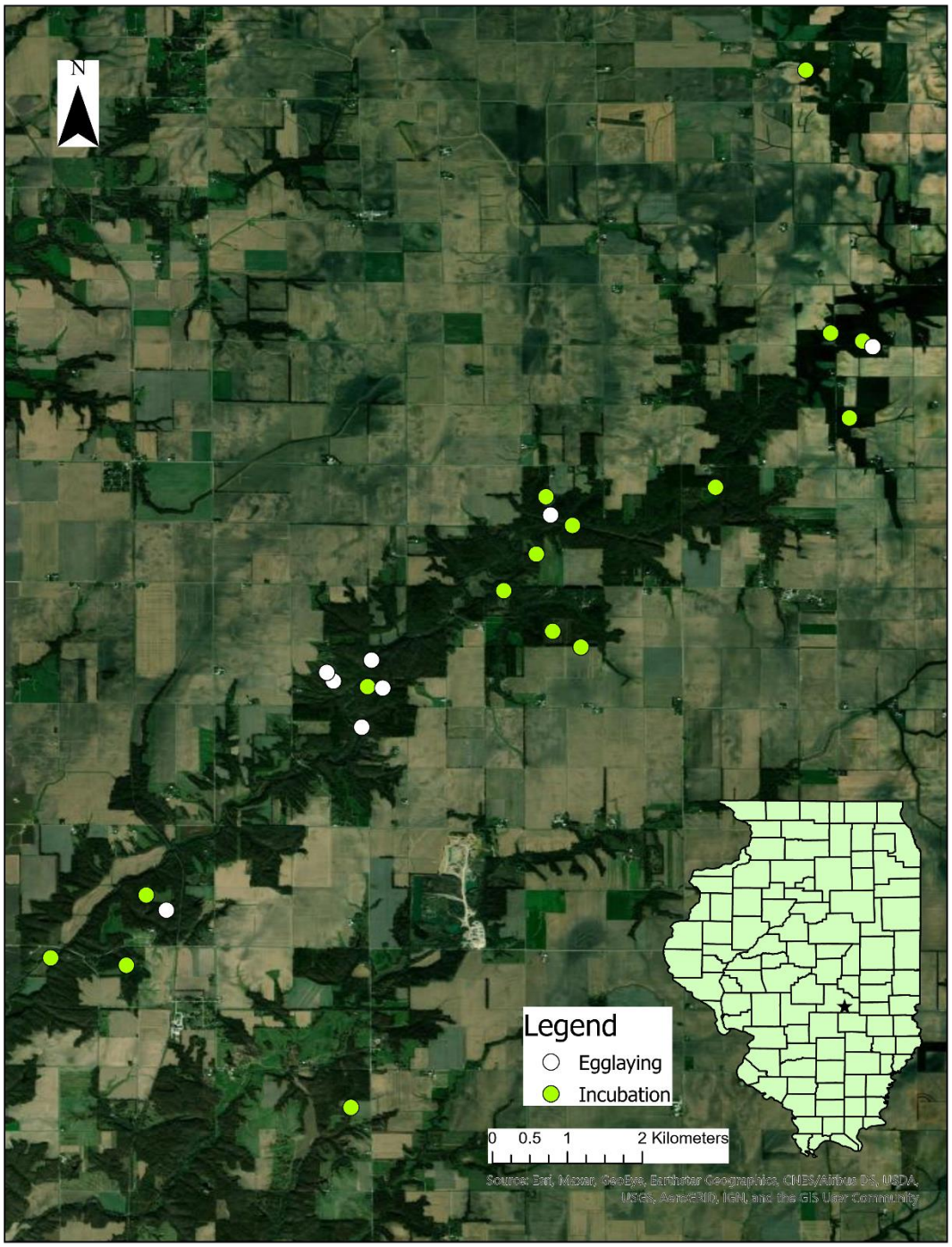

Figure 2. Nest locations at Hidden Springs State Forest Area, Shelby County, Illinois, USA, 2020. We separated egg laying attempts (white circles) from nests that were incubated (green circles).

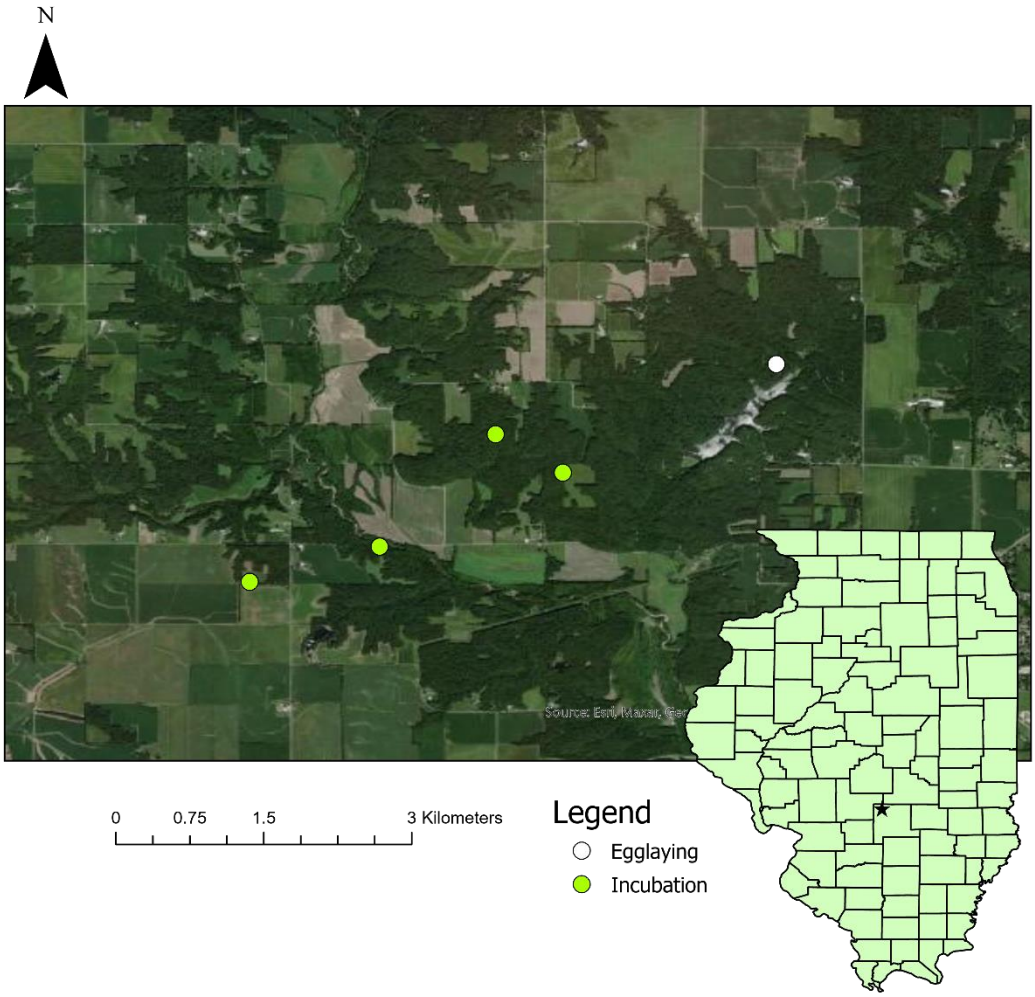

Figure 3. Nest locations at Ramsey Lake State Park, Fayette County, Illinois, USA, 2020. We separated egg laying attempts (white circles) from nests that were incubated (green circles).

Survival. There were 23 turkeys with active transmitters as of December 2019 (from the 2019 capture season). At the start of 2020, five turkeys tagged in 2019 were placed in the 'unknown' category due to assumed battery failure. Two hens from the 2019 cohort died prior to 15 March 2020, and the causes of their death were unknown. One radio-tagged and two banded males from the 2019 cohort were harvested from Hidden Springs and Syrcle Farms, respectively. Among the 2020 captures there were six female mortalities: (2) depredated during nesting (Ramsey Lake and Pasa), and (3) depredated prior to incubation (Table 4; Hidden Springs and

Pasa), and (1) depredated after nesting season (Ramsey Lake). Five males (Hidden Springs and Ramsey Lake) were depredated during the 2020 field season. Currently, 2 males and 18 females of the 24 GPS-tagged turkeys are still being tracked and their data downloaded.

Table 4. Counts and cumulative proportions of micro GPS-tagged turkeys (females and males combined) by status (A: alive, D: dead, or U: unknown) at the end of each date range in Hidden Springs, Ramsey, and Western Illinois (Syrcle, Pasa, and Twin Rivers) sites during three time periods during 2019-2020.

Date Ranges	**Hidden Springs**			**Ramsey**			**W. Illinois**		
Counts	**A**	**D**	**U**	**A**	**D**	**U**	**A**	**D**	**U**
1 Jan – 15 Mar	20	4	3	8	2	0	12	1	2
16 Mar – 15 Jun	16	1	3	5	3	0	8	2	2
16 Jun – 31 Aug	14	1	1	4	1	0	8	0	0
Cumulative Proportion									
1 Jan – 15 Mar	0.74	0.15	0.11	0.80	0.20	0.00	0.80	0.07	0.13
16 Mar – 15 Jun	0.59	0.19	0.22	0.50	0.50	0.00	0.53	0.20	0.27
16 Jun – 31 Aug	0.52	0.22	0.26	0.40	0.60	0.00	0.53	0.20	0.27

Nest Site Vegetation. A summary of the visual obstruction measurements associated with nests and randomly chosen points 80 m from each nest are given in Table 5. Hens place nests locally in locations providing more cover (i.e. concealment) from a distance of 15 m away. This pattern held across all three height categories. There were 20 additional coverboard (visual obstruction) surveys completed each at Hidden Springs and Ramsey Lake. Each of 4 management categories was surveyed 5 times at each site. Overall, visual obstruction (i.e., vegetation cover) was similar in the lowest height category between sites, but significantly more at Hidden Springs in the middle and highest height categories (Figure 4). Among the forest management categories, the visual obstruction values that best matched those of our hen turkey nests were found in non-managed portions or forest units having had exotic shrub and maple

control at Hidden Springs (Figure 5), and in forest units several years (since 2012) after prescribed fire or units having had prescribed fire and thinning a few years ago at Ramsey Lake (Figure 6).

Table 5. Vegetation characteristics for 2020 turkey nests (n=31) and paired random points 80 m away. Statistics are from paired *t*-tests (two-tailed). Higher obstruction values represent higher amounts of cover.

	Mean			
Characteristic*	Nest	Non-Nest	*t*	*P*
Obstruction (0-0.5m height) from 15 m away	5.5	4.9	3.8	<0.001
Obstruction (0.51-1.0m height) from 15 m away	4.2	3.7	2.69	0.008
Obstruction (1.01-2.0m height) from 15 m away	2.9	2.5	1.97	0.05

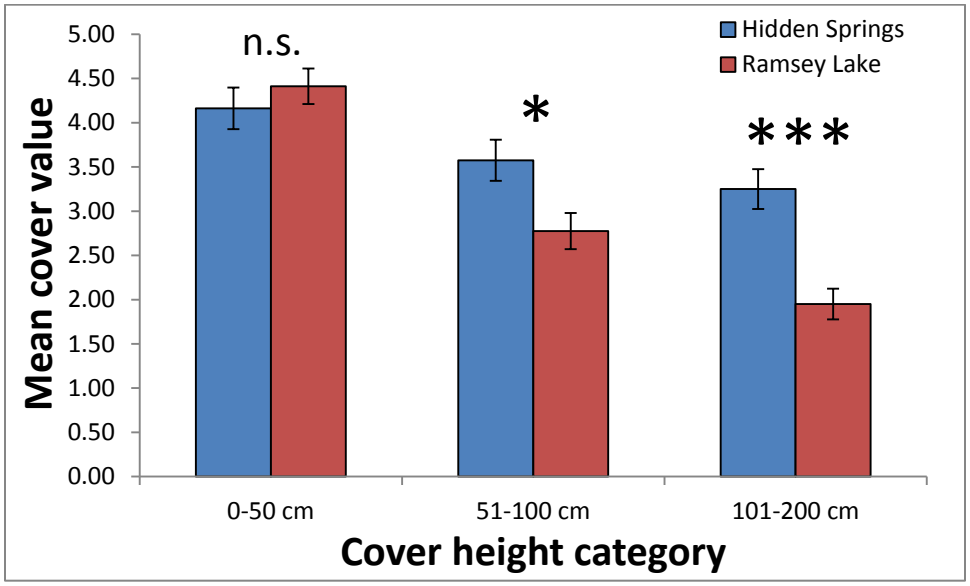

Figure 4. A comparison of overall visual obstruction values measured at Hidden Springs State Forest and Ramsey Lake State Park, Illinois, USA, 2020. Means and standard errors given; n.s. = $P>0.05$; * = $P<0.05$, *** = $P<0.001$ for comparisons between the two sites within each height category.

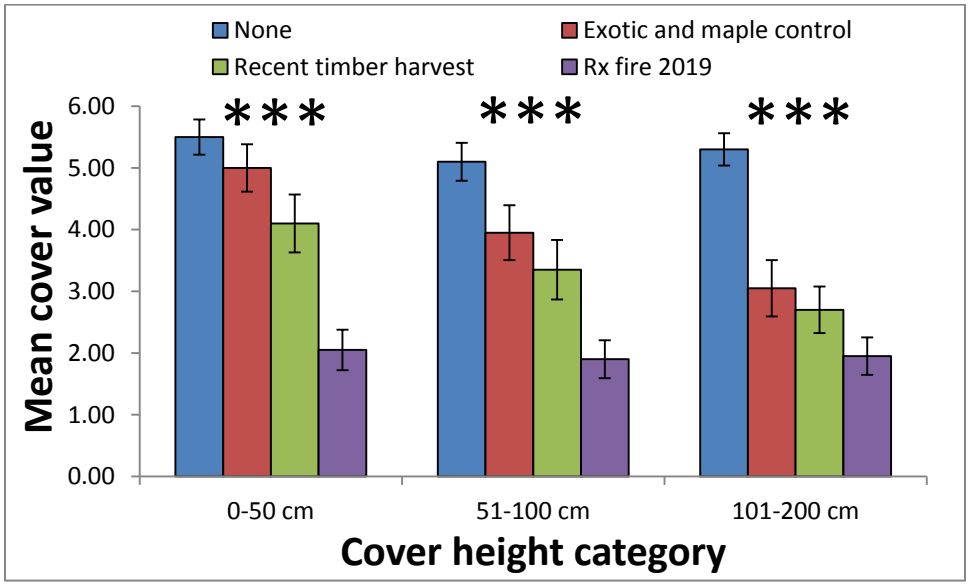

Figure 5. A comparison of overall visual obstruction values measured at Hidden Springs State Forest, Illinois, USA, 2020. Means and standard errors given; *** = $P<0.001$ for comparisons between the management categories within each height category.

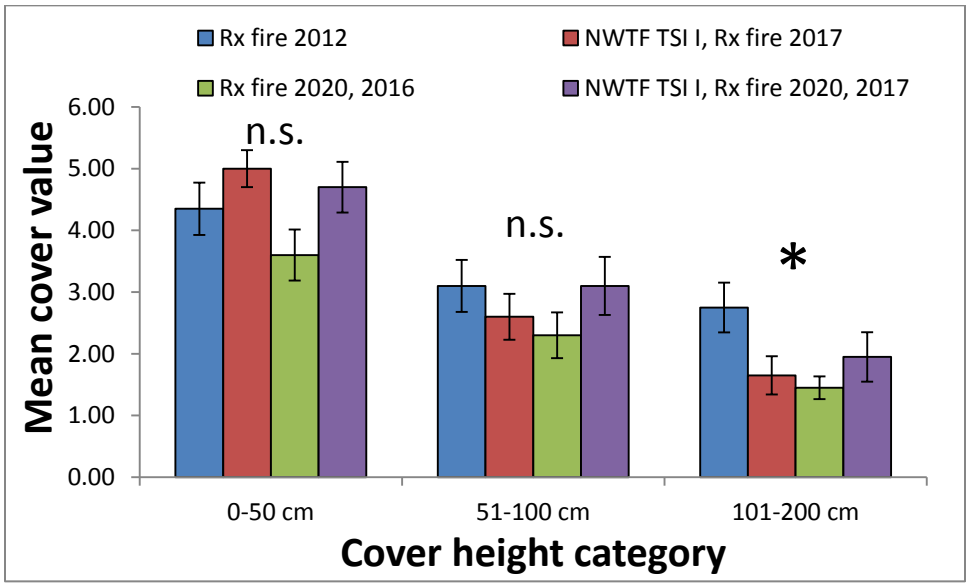

Figure 6. A comparison of overall visual obstruction values measured at Ramsey Lake State Park, Illinois, USA, 2020. Means and standard errors given; n.s. = $P>0.05$; * = $P<0.05$ for comparisons between the management categories within each height category.

Black Fly Monitoring. Due to travel and building access restrictions as a result of COVID-19, we were unable to deploy blackfly traps for the 2020 field season. We were able to get a rough estimate of blackfly abundance throughout the sites (Twin Rivers Inc., Pasa, Hidden Springs, and Ramsey Lake). Before blackfly emergence, we developed a scale from 1 to 5 (Table 6) to subjectively rate blackfly abundance in the context of harassment level. Technicians rated sites each week (week 18 – 26; Table 6). Similar to previous field seasons, the western sites had the highest rating of black fly abundance (Figure 7) and the timing an pattern of emergence was qualitatively similar to years when fly traps were deployed.

As discussed in our previous reports, black fly emergence overlaps the reproductive period of wild turkeys; however, black flies emerge each year well after turkey hens have started laying eggs and the overlap between black flies and nesting hens occurs later in the incubation stage and brood rearing stage as demonstrated in the 2019 data (Figure 8). Western Illinois continues to have tremendous amounts of black flies emerging during the summer compared to the relatively few in south central Illinois. Regardless, at this point, there is no indication that black fly abundance affects the daily nest survival of turkeys ($P = 0.29$). Additional results will be reported in upcoming manuscripts, one of which has a draft nearly completed.

Table 6. Scale used to qualitatively rate index of blackfly abundance for 2020 field season, Illinois, USA.

Scale	Level of Black Flies
1	Did not notice flies
2	Start to notice flies, but relatively few
3	Flies are present; starting to notice bites
4	Flies are present; annoying; may need a head net
5	Flies are outrageous; cannot go without head net; constantly being swarmed

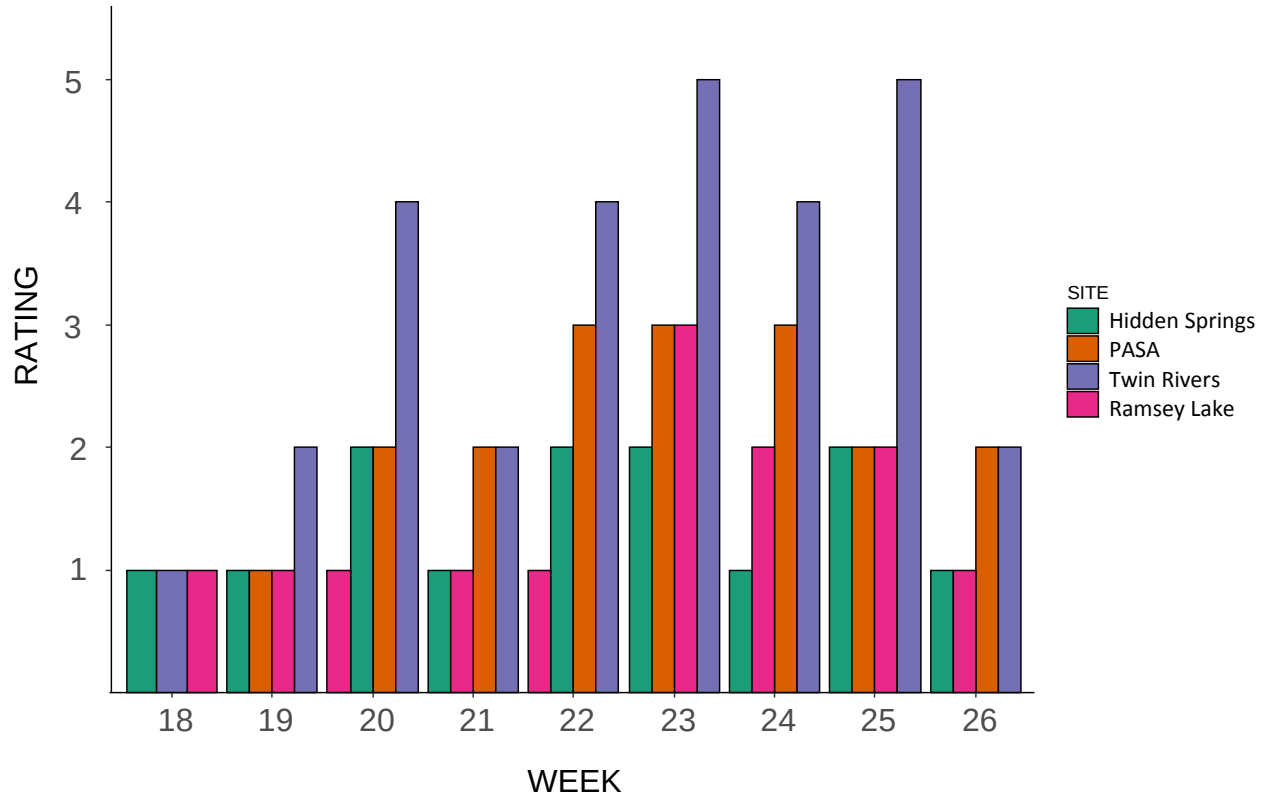

Figure 7. Index of blackfly abundance on a scale of 1-5 in Pike (Twin Rivers and Pasa), Fayette (Ramsey), and Shelby Counties (Hidden Springs), Illinois, USA for 2020. See **Table 6** for explanation of ratings (scale).

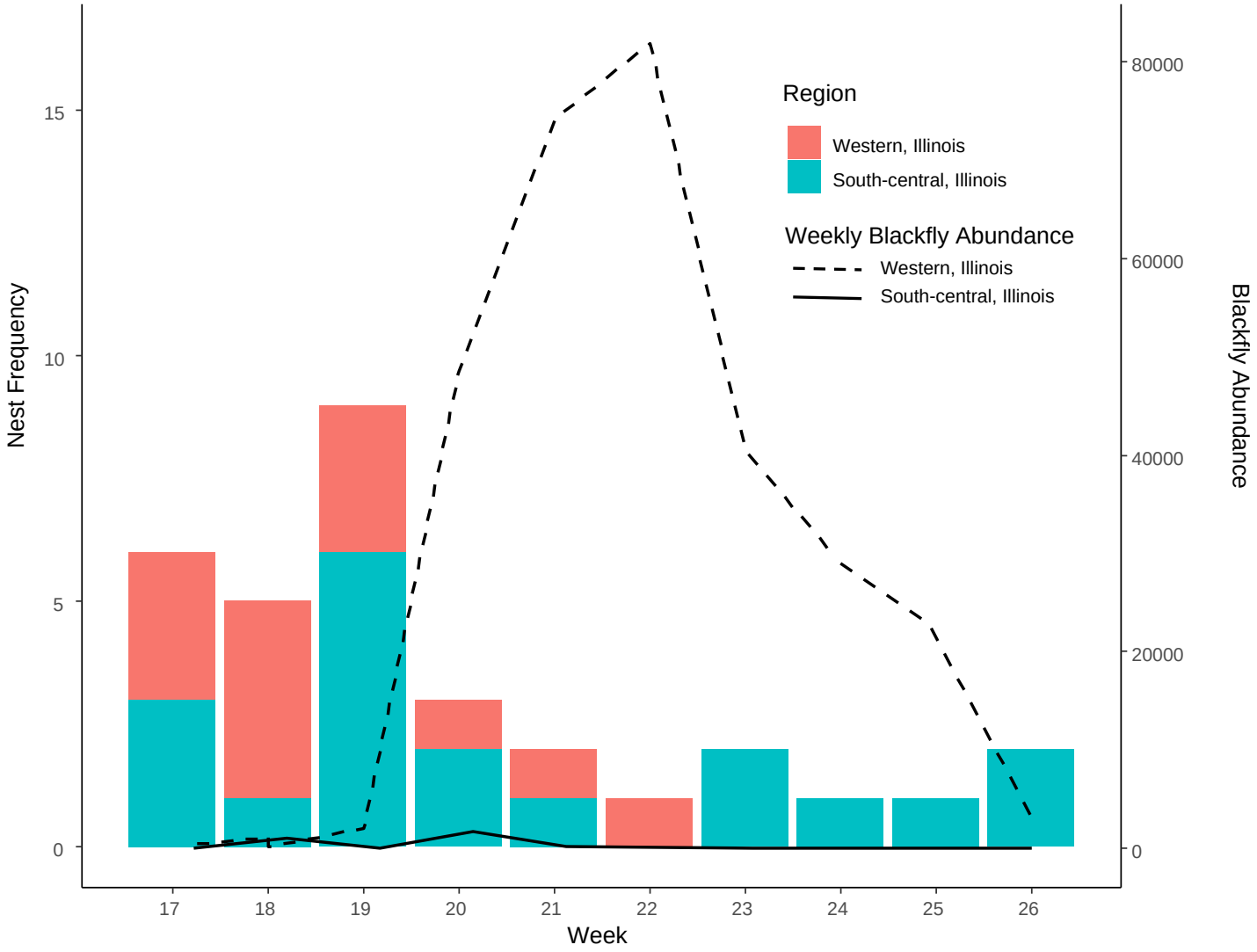

Figure 8. Cumulative number of nests initiated weekly (i.e. start incubation) in the western and south-central regions of Illinois overlaid with the weekly black fly abundance for the respective region in Illinois, USA, for 2019.

Camera Trap Data. Raccoons, followed by opossums, had the highest detection rates among predators "captured" by camera traps and the capture rates were not significantly different among the four sites where cameras were deployed (Figure 8). Pertaining to these two meso-predators, both regions (western vs. south-central Illinois) had similar capture rates. In south-central Illinois, Ramsey Lake cameras captured a few coyotes and a bobcat while the Hidden Springs cameras captured a bobcat and a fox (Figure 8). The western Illinois cameras deployed on private land did not capture these three additional predator species. This result indicates that the nests of hen turkeys may equally vulnerable to predation between the south-central and western Illinois regions, and we did not see a difference in nest success between the two regions. The presence of predators that could take adult turkeys, while rarely captured on cameras, was only documented on the sites in south-central Illinois. This could explain, in part, why a fair number of turkeys (particularly young males) were depredated at Ramsey Lake and Hidden Springs. The cameras also captured a lot of white-tailed deer and gray squirrels. For these two species, white-tailed deer were ubiquitous across all sites, whereas gray squirrels were captured at significantly higher rates in the south-central region on the state-owned managed forests at Hidden Springs and Ramsey Lake.

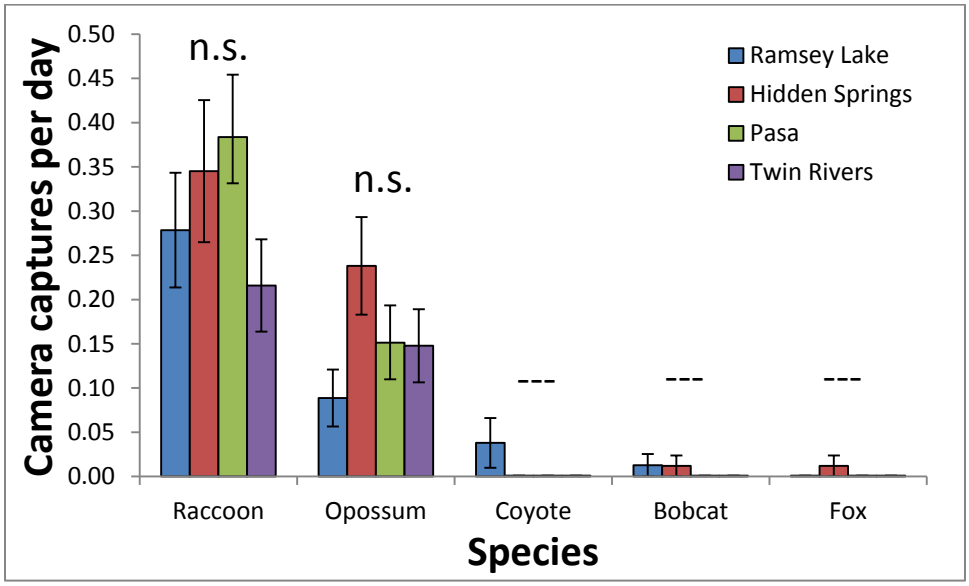

Figure 9. Detection rates for various potential predators of nest/hen/poult turkeys "captured" at camera traps deployed on four sites in Illinois during May - June 2020. Means and standard errors depicted; n.s. = $P>0.05$, --- = not enough data for statistical analysis.

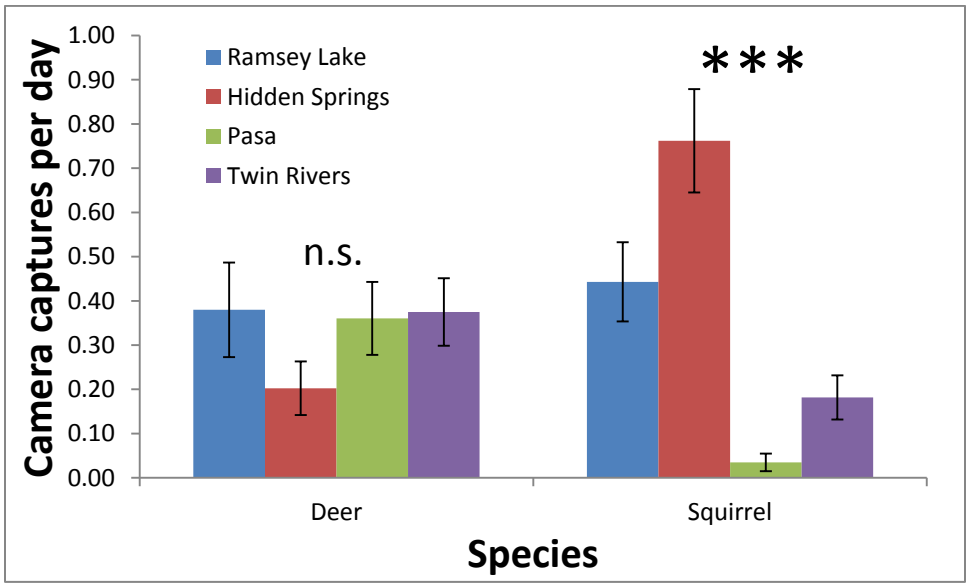

Figure 10. Detection rates for two game species "captured" at camera traps deployed on four sites in Illinois during May - June 2020. Means and standard errors depicted; n.s. = $P>0.05$, *** = $P<0.001$.

Habitat Selection. Figures representing data summaries and analyses associated with turkey hen habitat selection are provided in an Appendix. Non-burned forest represented a large proportion of the areas used by and available to wild turkey hens (see Appendix Tables A.3, A.6, A.9), yet the data did not support our prediction that hens would prefer burned over non-burned areas. Instead we found that burned and non-burned forests were used in proportion to their availability, with the exception of post-nesting core areas where burned areas were favored. This simple evaluation of burned versus non-burned forest underscores the importance of non-burned forests in a prescribed fire management scheme where wild turkeys are present. The value of non-burned habitat is noticeably absent in other studies of turkey habitat selection in fire-managed systems (Martin et al. 2012, Kilburg et al. 2015). However, this is likely due to the nature of the questions investigated, analytical design, and perhaps ecosystem differences. Although we did not have a sufficient sample size to evaluate habitat selection impacts on nest success, Pittman and Krementz (2016) observed greater nest success among hens that nested in non-burned areas, and detected differences in nest-site selection among hens in upland hardwood forests in Missouri. Taken together with our study, these results indicate that non-burned forests are an important component of forests managed with prescribed fire, and emphasize the value of non-burned forest for nesting turkeys.

Our results are consistent with the habitat-complementation hypothesis of pyrodiversity (Kelly et al. 2017). Turkey home ranges and core areas were composed of multiple fire elements (See Appendix A). These pyrodiverse landscapes provided the heterogeneous structure needed by turkey hens during the reproductive season. During the egg-laying and incubation periods, hens preferred areas that had experienced at least one growing season over current year burns. This avoidance of current year burns is contrary to the idea that hens would be attracted to those areas by the flush of spring growth after dormant season burns (Wilsey 1996, Meek et al. 2008). With fewer live shrubs and reduced understory foliage (1.5 – 10m), recent burns may be

unsuitable habitat for wildlife with young searching for cover (Blake and Schuette 2000). For example, current-year burns were avoided by white-tailed deer (*Odocoileus virginianus*) in North Carolina during the lactation period, when deer with fawns seek areas with sufficient cover from predators (similar to nesting or brood-rearing turkeys; Lashley et al. 2015). While hens included in our study may have used recent burns during the reproductive season, no hens nested within recently burned areas. Only two turkey nests (both unsuccessful) were located in managed areas, and each had experienced one growing season prior to the time of nesting.

Burn regime influenced habitat selection among wild turkeys as well as the composition of burned areas used at different temporal scales (See Appendix). Similarly, Wood et al. (2018) found that hen habitat selection varied throughout the reproductive season, and hens exhibited habitat preferences in response to time-since-burn and stand seral stage in pine forests. In our study, areas with a single growing season since burning were often preferred, likely because these areas support the growth of herbaceous understory vegetation that turkeys can use as forage and cover (Hutchinson et al. 2005). Following multiple growing seasons, however, vegetation density and cover may increase and the abundance of important forage plants (e.g., seed-bearing grasses, fruit-bearing forbs) may decline as woody shrubs and saplings limit the amount of light reaching these sun-loving plants (Hutchinson et al. 2005, Albrecht and McCarthy 2006). Diet composition data indicate that wild turkeys in Missouri consumed a large proportion of forbs and grasses (more than 40% of their diets) from mid-July through mid-October, which generally falls into the post-nesting period of our analyses (Dalke et al. 1942). The composition of post-nesting home ranges and core areas included a greater proportion of areas with higher burn frequencies (see Tables A.5, A.8, A.11). While these areas were used in proportion to their availability, the broad-scale use of these frequently burned areas throughout the annual cycle suggests their importance for wild turkeys during the reproductive periods, presumably for foraging.

(iii) Reasons Estimated Goals Were Not Met

The one goal that we did not meet was to quantify black fly numbers weekly using CO2 (dry ice) traps. As mentioned earlier, due to travel and building access restrictions as a result of COVID-19, we were unable to deploy blackfly traps for the 2020 field season. We instead developed a method that allowed the technicians to qualitatively assess blackfly abundances throughout the sites (Twin Rivers Inc., Pasa, Hidden Springs, and Ramsey Lake) while making weekly visits to sites during April – June.

(iv) Additional Pertinent Information

Turkeys with active µGPS units will continue to be monitored every 2 weeks. Continuing to have three Netblasters will allow us to be as successful as we can be at capturing hens during the relatively brief winter capture season. Examples of presentations and posters given at conferences, as well as other forms of public outreach, were provided in the Quarterly Progress Reports during this segment.

(v) Significant Developments

Not Applicable

(vi) Executive Summary

a) We continued to document locations and fates and nesting attempts of 23 wild turkeys captured in the winter/spring of 2019 whose radios continued to function into the spring of 2020.

b) During the winter/spring of 2020 we captured and banded 29 wild turkeys among 3 study sites and fitted 22 hens (at various sites) and 7 males (at various sites) with a μGPS transmitter.

c) On average each active transmitter has recorded over 1,500 locations to date that are accurate enough to allow us to know where and when hens were laying eggs, incubating eggs, the fates of those nests, and seasonal habitat use at finer- and larger-scales. This will allow us to model how land use and forest management (at Hidden Springs and Ramsey Lake) affects the nesting success, survival, and habitat selection of hen turkeys.

d) Of the 22 hens captured in 2020, six suffered mortality: (2) depredated during nesting, (3) depredated prior to incubation, and (1) depredated after the nesting season. Overall, hen turkeys continue to be particularly vulnerable to predation during the lead up to nesting and during incubation phase of the nesting period.

e) Twenty-six of 35 nests failed to make it to the poult stage. Six succeeded to the poult stage (poults observed with hen); three were classified as unknown (could not determine fate due to land-access issues). The six successful nests (poults observed), plus the 3 making it to day 28 of incubation and possibly being successful, is the highest rate of success we have had to date. Ten nests failed during egg laying (i.e. abandoned or depredated), 14 incubated nests were depredated, and two nests failed due to hen mortality. Nine of the 35 attempts were unsuccessful renests. A tagged hen made 4 nesting attempts during the 2020 season, which was a first for the project. Based on visitation to baited camera traps, suspected nest predators include raccoons, opossums, coyotes, foxes and bobcats.

f) We collected another year of accelerometer data from nesting turkey hens in western Illinois sites (where black flies were abundant) and south-central Illinois sites (where black flies were relatively uncommon), and will analyze it to see if black flies influence incubation behavior of turkey hens in ways that may make them or their nests more vulnerable to predation.

g) Data confirm that black flies are very abundant in western, but not south-central Illinois. The flies emerge after turkey hens have started laying eggs and so have little/no effect on nest placement. Peak black fly abundance occurred during the part of the breeding season when many hens are incubating eggs or tending young poults. Analyses of nest survival as a function of black fly abundance currently show no evidence of direct or indirect effects of black flies on wild turkey reproductive success during the incubation stage.

h) Finally, the programming and database structure we now have in place will be used to assess the effects of land-cover configuration, forest structure and composition, and forest management history on hen and nest survival rates as well as seasonal and annual habitat selection at multiple scales (e.g. home ranges within landscapes, and activity hotspots within home ranges).

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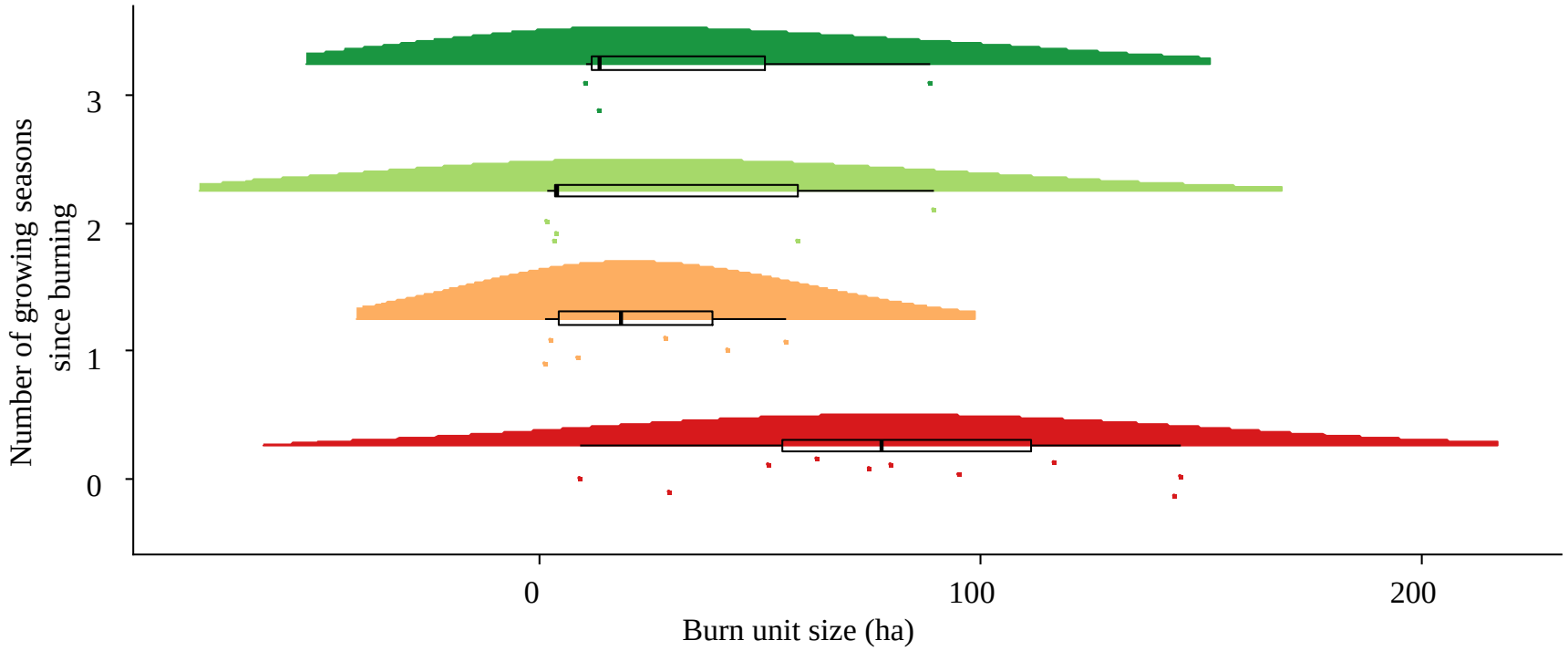
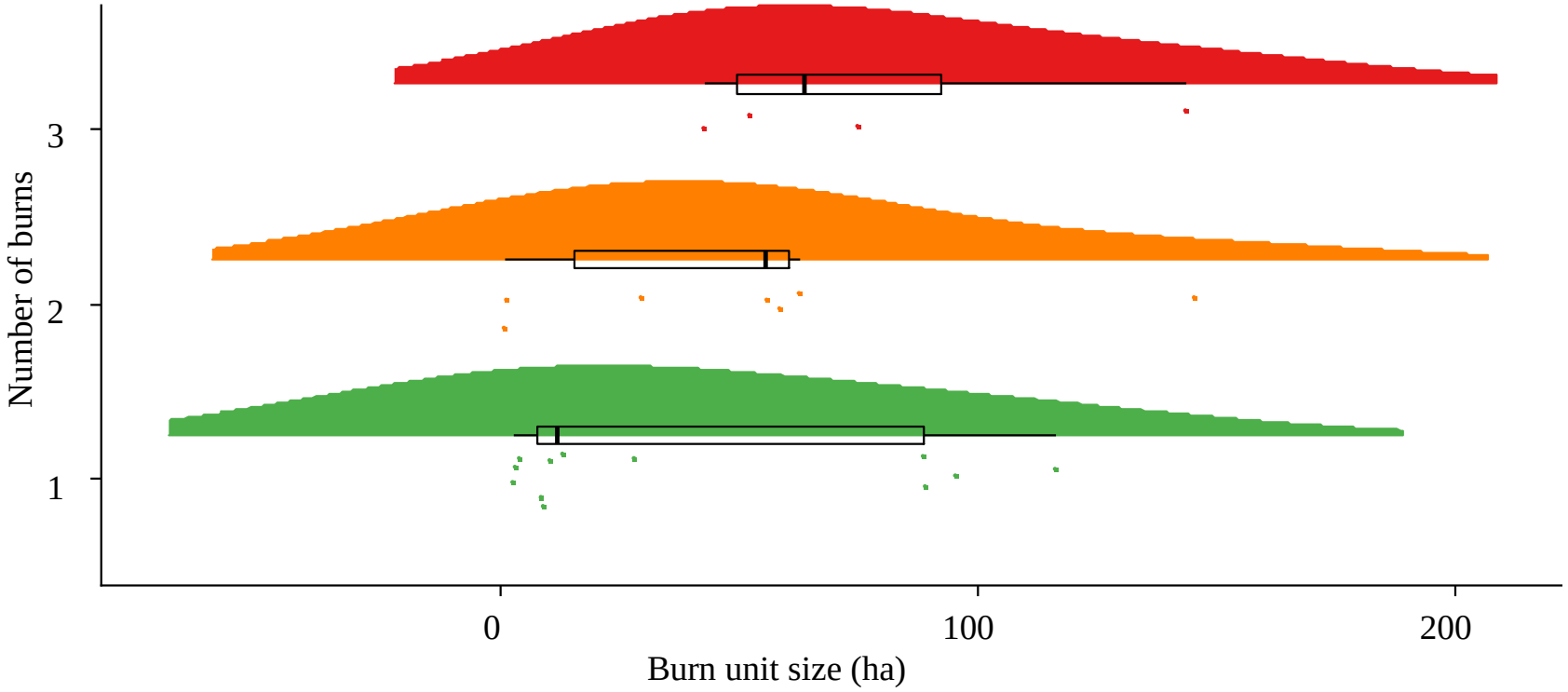
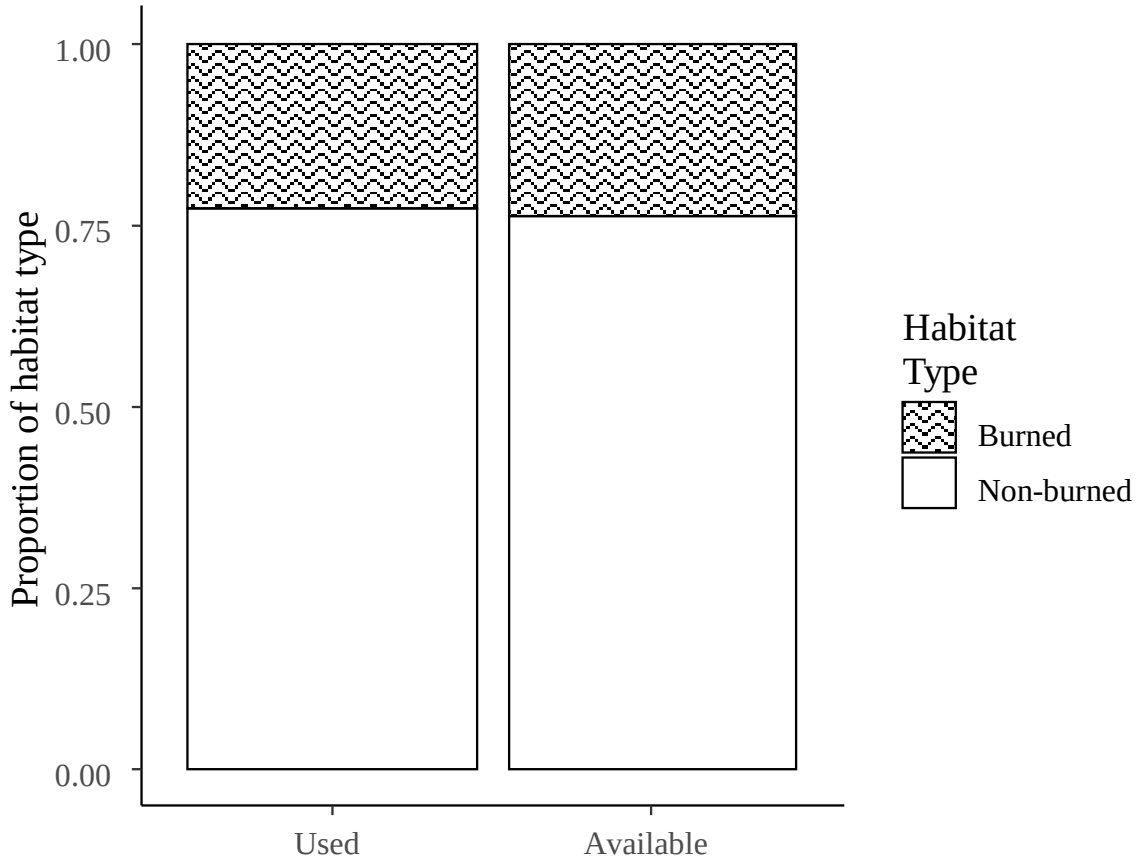
Appendix



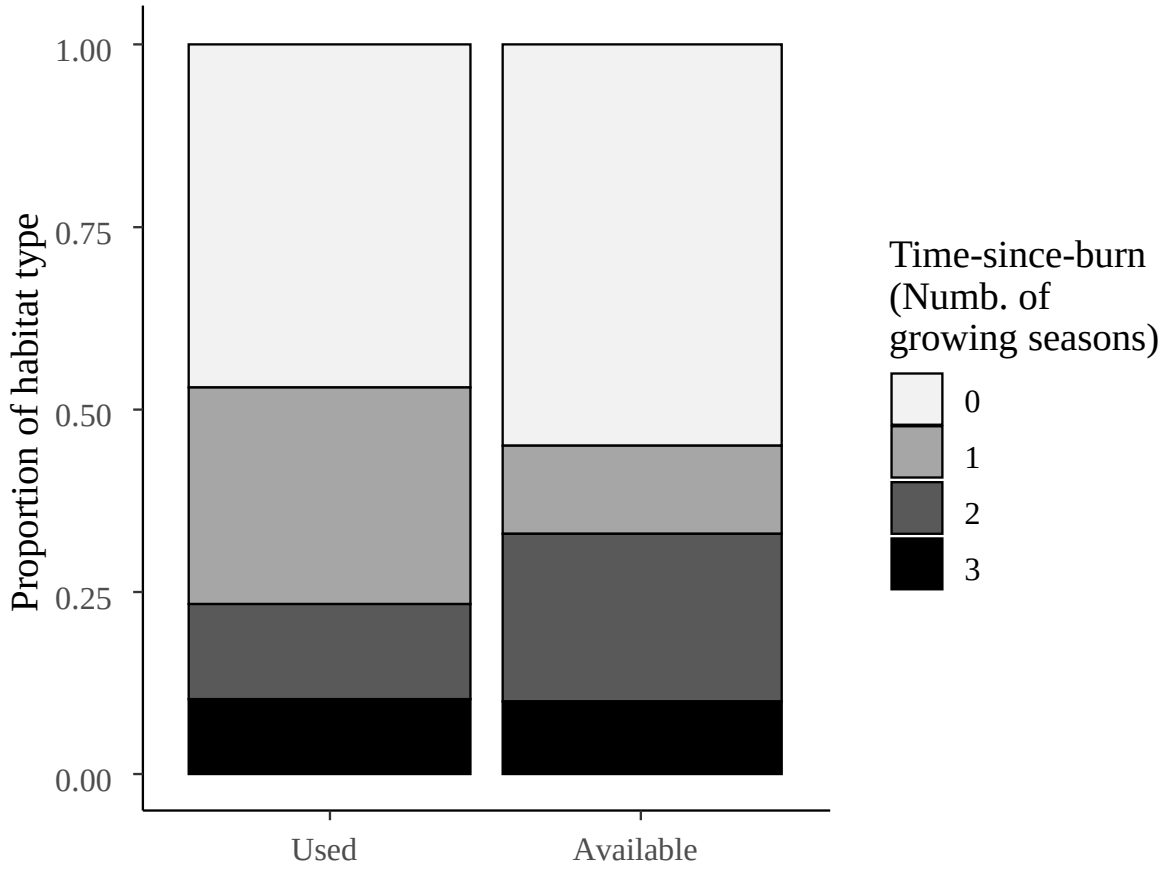
A. 1. Rain cloud plot of burn unit sizes (ha) categorized by time-since-burn, or the number of growing seasons since burning. The "cloud" illustrates the probability distribution of burn sizes, the "rain" illustrates the raw burn unit sizes, and the box plots provide additional statistics describing burn sizes.



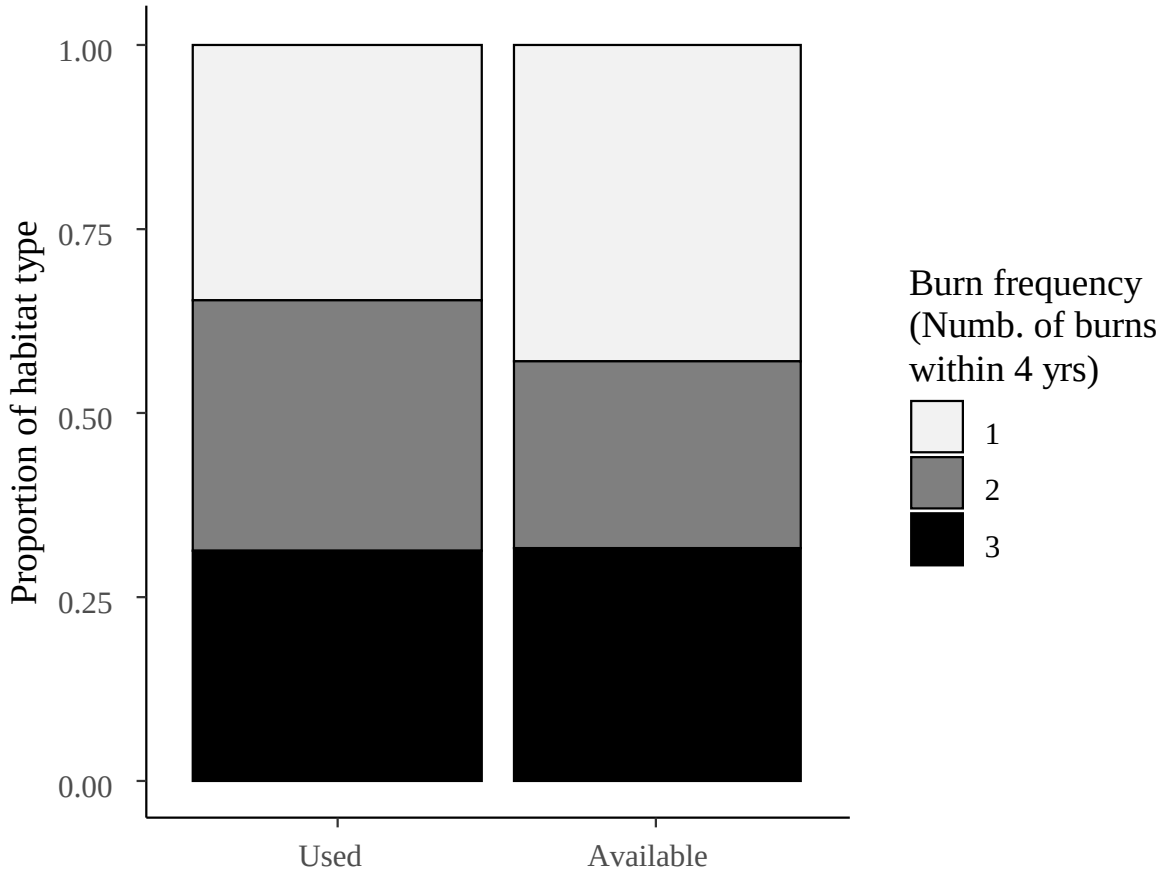
A. 2. Rain cloud plot of burn unit sizes (ha) categorized by burn frequency, or the number of burns within four years. The “cloud” illustrates the probability distribution of burn sizes, the “rain” illustrates the raw burn unit sizes, and the box plots provide additional statistics describing burn sizes.



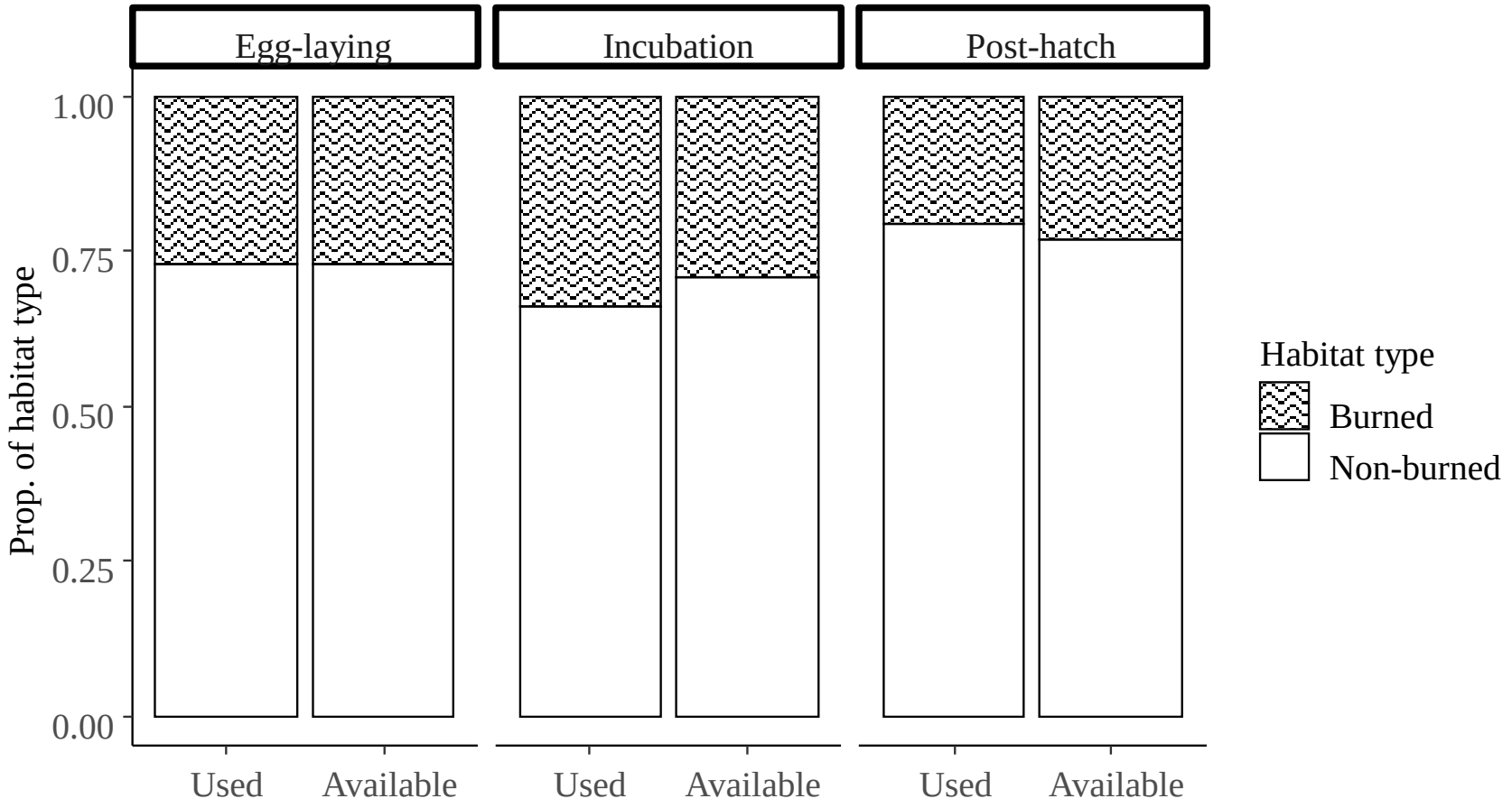
A. 3. Proportion of habitat (burned vs. non-burned forest) within individual annual ranges (Used) and flock annual ranges (Available) among all years, 2015 – 2017.



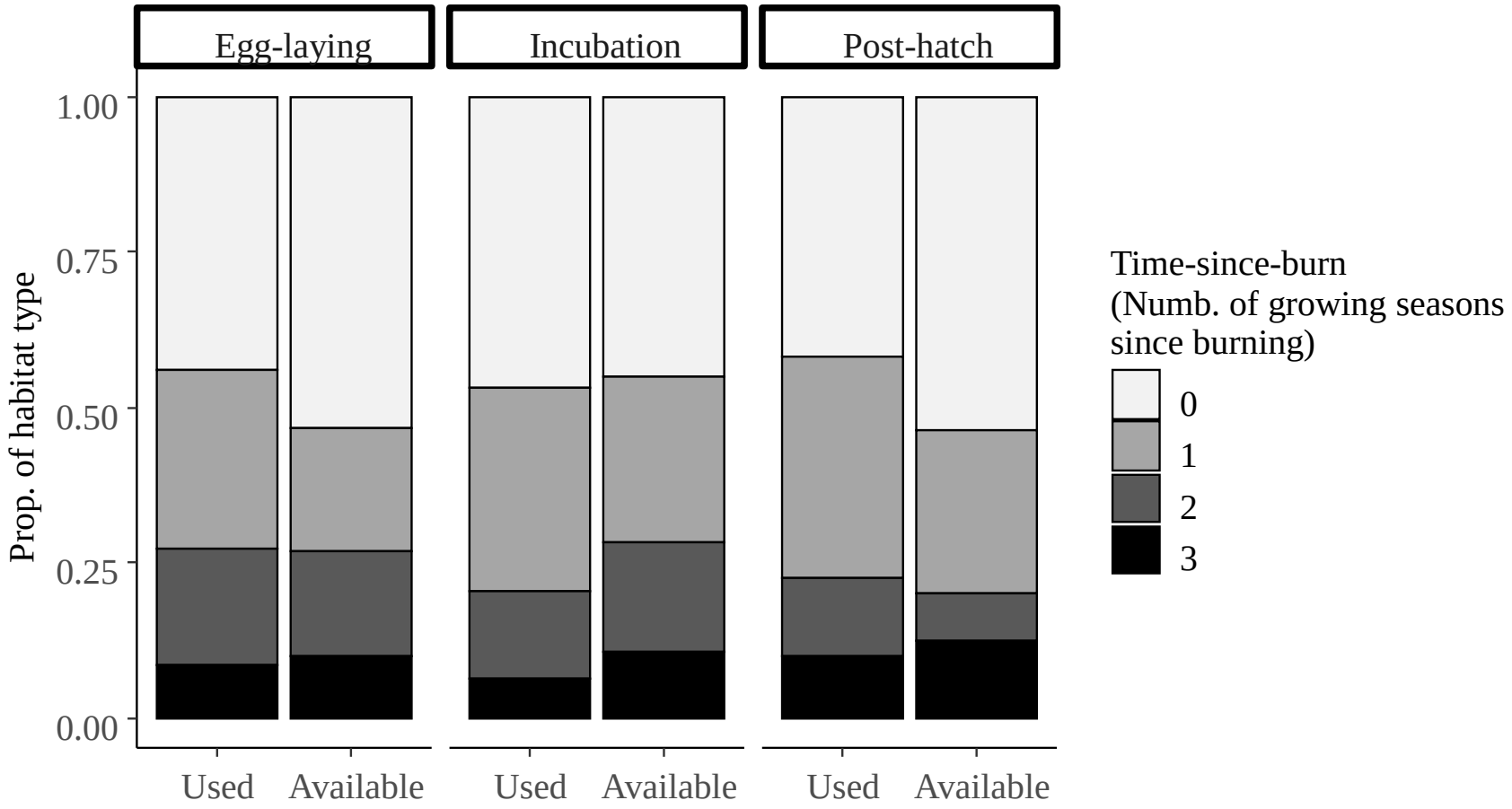
A. 4. Proportion of burned forest (categorized by time-since-burn) within individual annual ranges (Used) and flock annual ranges (Available) among all years, 2015 – 2017.



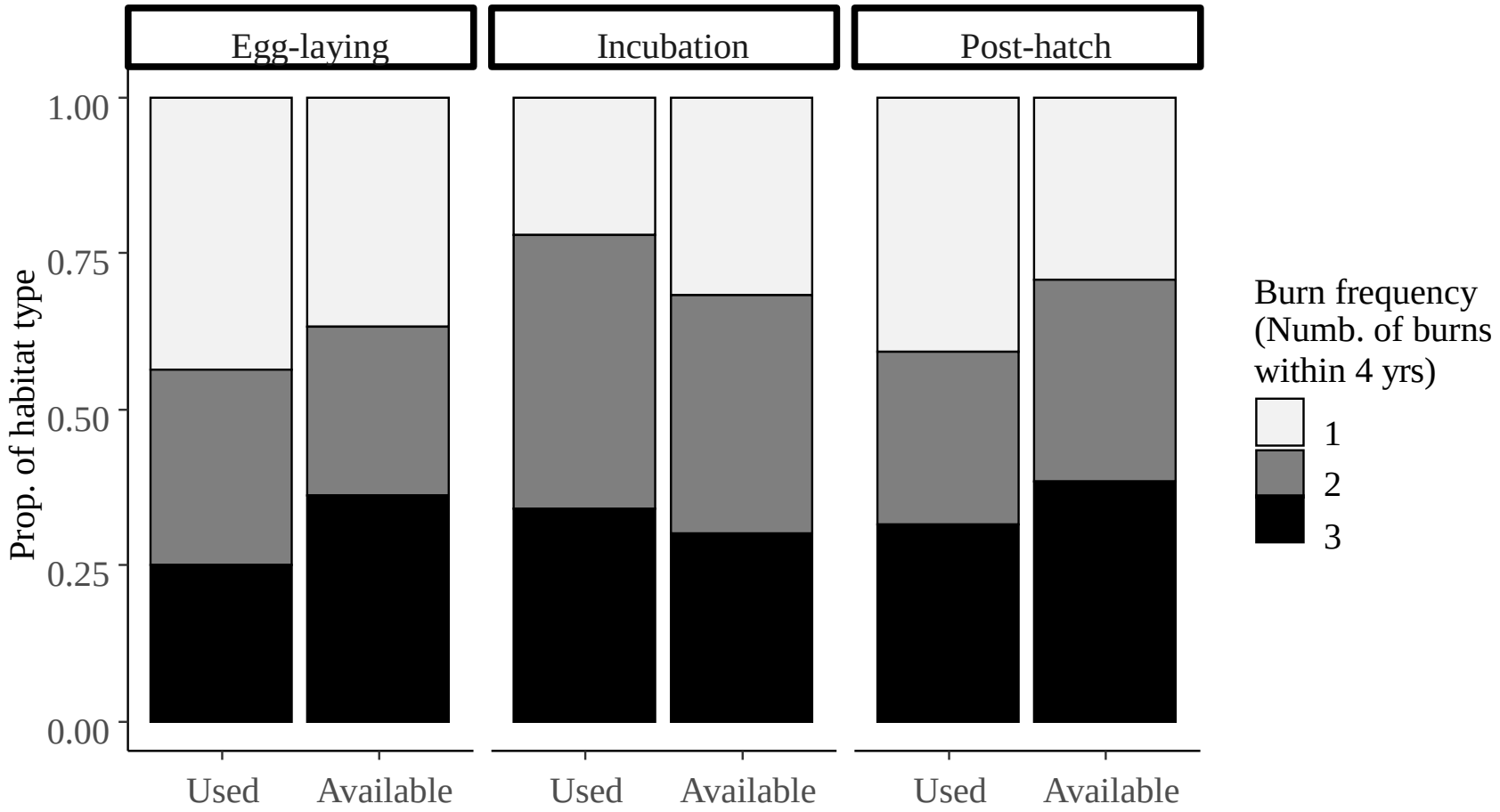
A. 5. Proportion of burned forest (categorized by burn frequency) within individual annual ranges (Used) and flock annual ranges (Available) among all years, 2015 – 2017.



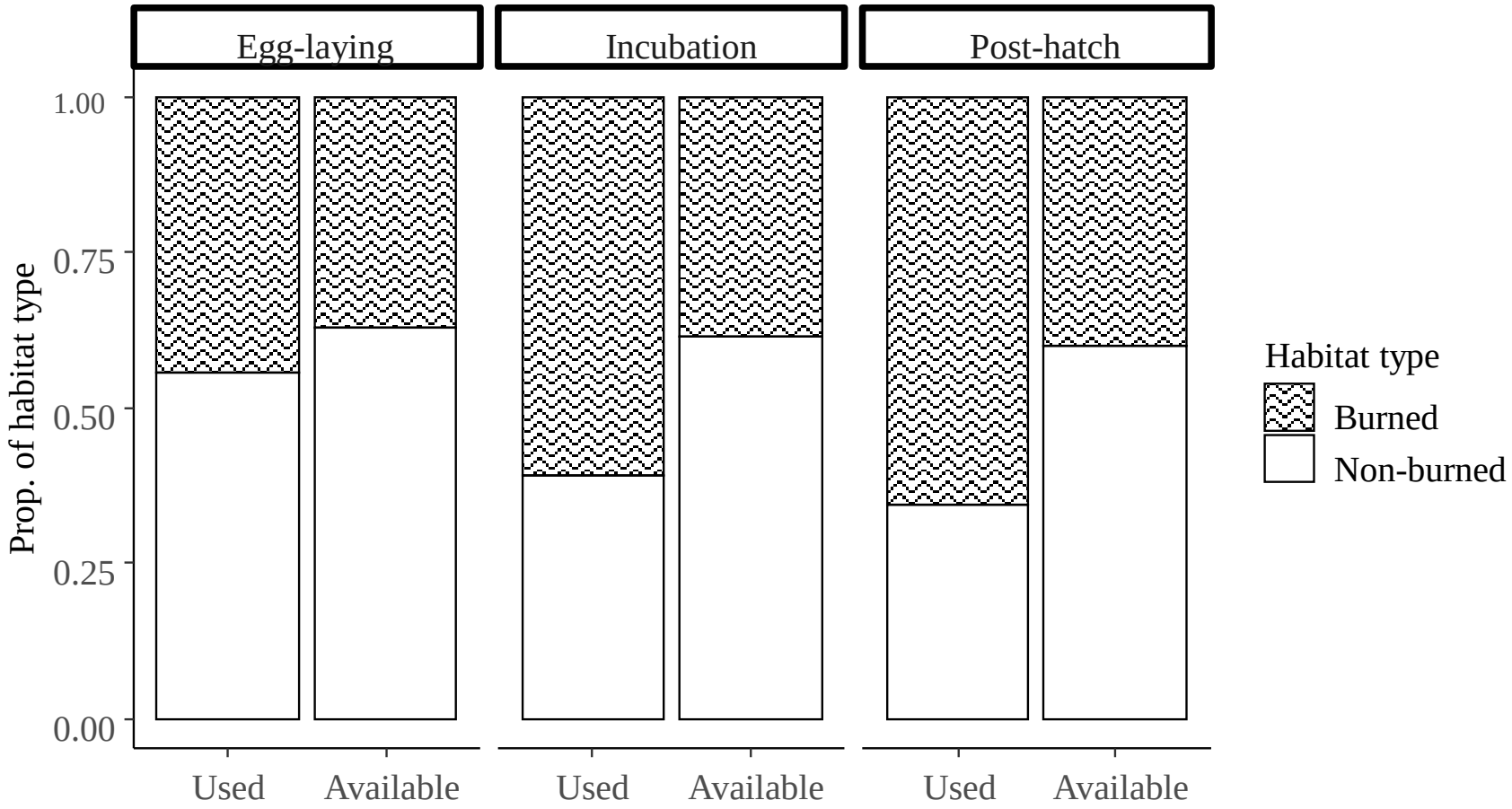
A. 6. Proportion of habitat (burned vs. non-burned forest) within individual 95% seasonal ranges (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.



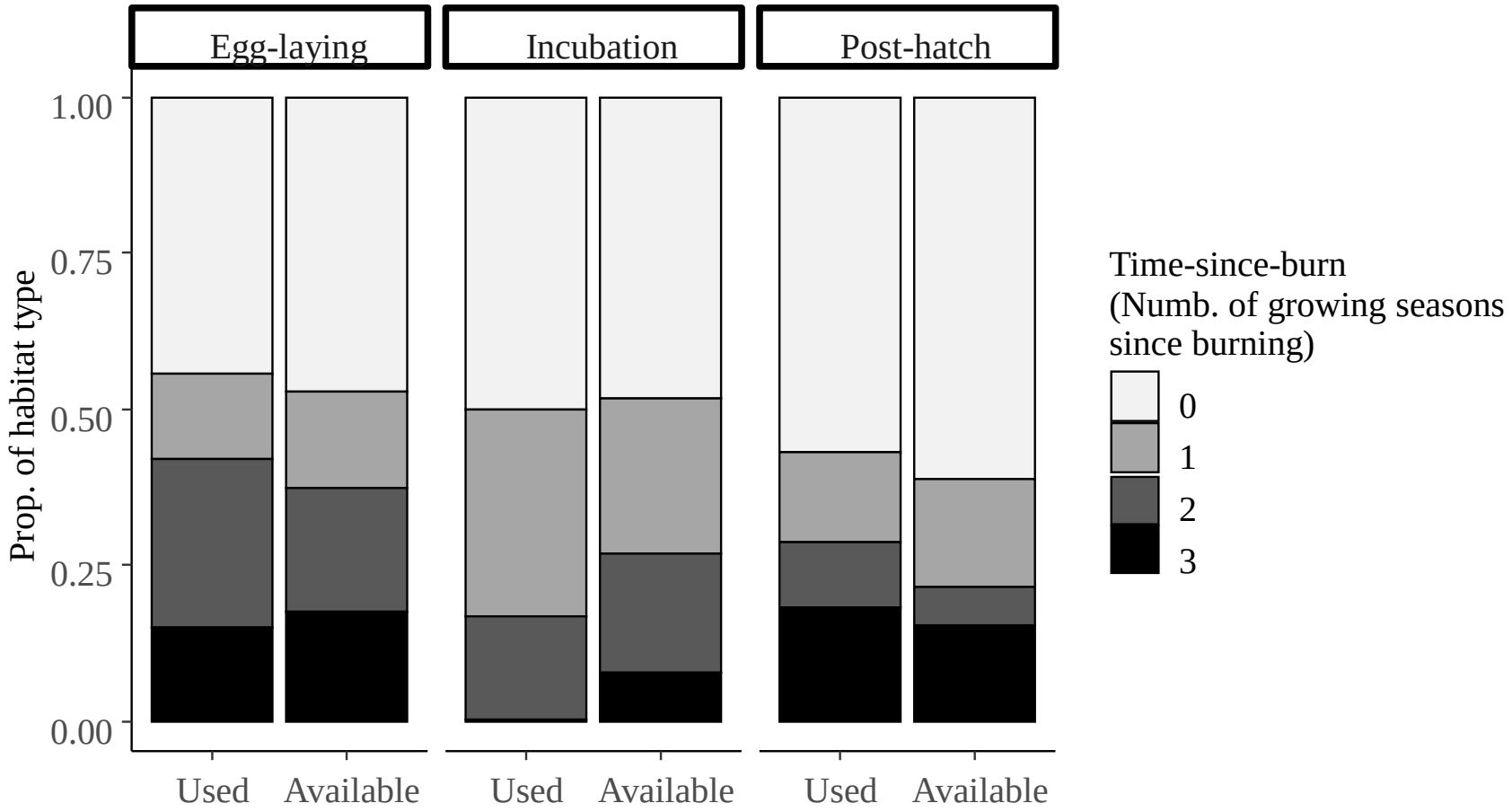
A. 7. Proportion of burned forest (categorized by time-since-burn) within individual 95% seasonal ranges (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.



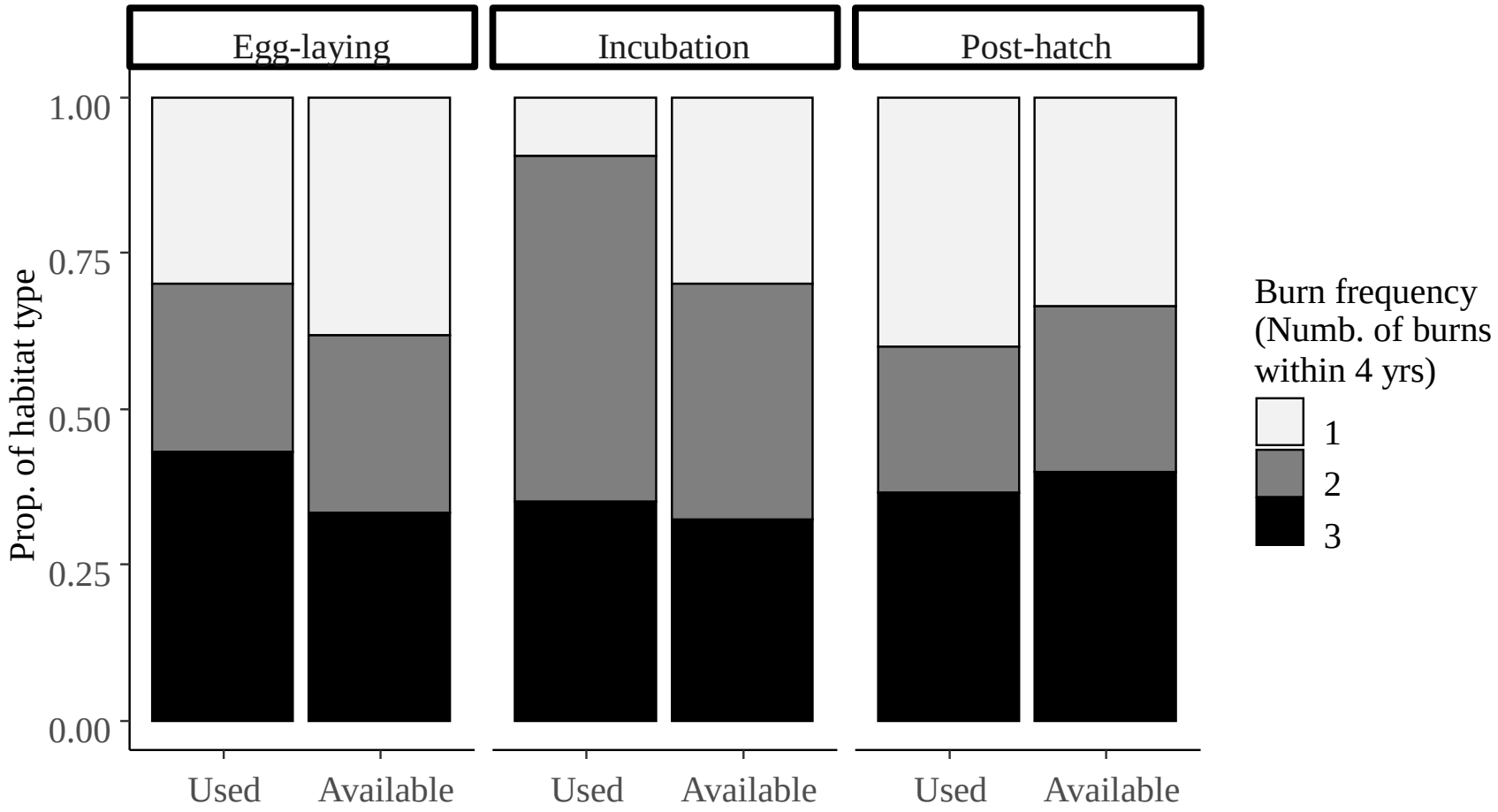
A. 8. Proportion of burned forest (categorized by burn frequency) within individual 95% seasonal ranges (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.



A. 9. Proportion of habitat (burned vs. non-burned forest) within individual 50% seasonal core areas (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.



A. 10. Proportion of burned forest (categorized by time-since-burn) within individual 50% seasonal core areas (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.



A. 11. Proportion of burned forest (categorized by burn frequency) within individual 50% seasonal core areas (Used) and composite of all individual seasonal ranges (Available) among all years, 2015 – 2017.